(54) **Measuring surface roughness**

(57) A housing 1 on an adjustable support 2 incorporates a lighting source 4 for projecting a light beam at an angle onto a rough surface 3, e.g. skin. Reflections from the surface 3 are observed by a video camera 5 whose output is led to a control unit 6 incorporating a microprocessor for analysing the signals and displaying a trace of the surface texture on a screen 7. A roughness value is calculated by analysing the light density variation along a line portion of the surface and comparing this with a standard value. The reflections may instead be photographed and light transmitted through the negative along the line portion. A graphical trace of the light density may be made and the roughness value taken as the trace length or calculated from the mean peak to peak frequency or amplitude, the integral of the area to both sides of the mean or from a Fourrier analysis.
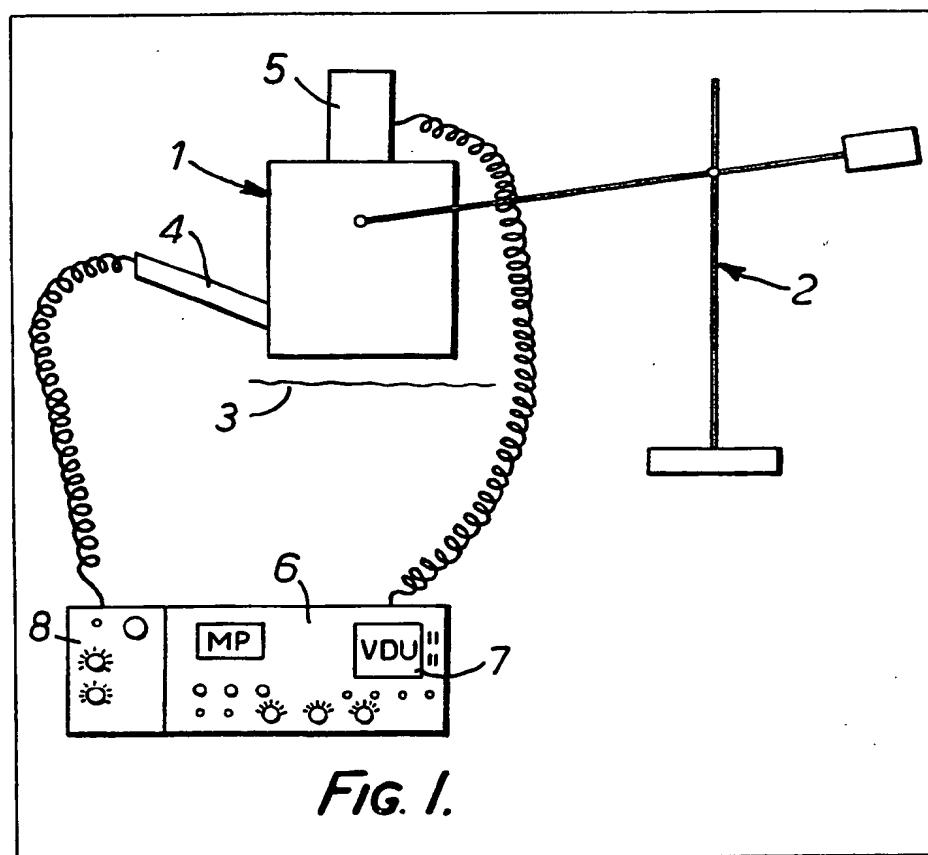

FIG. 1.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.
This print takes account of replacement documents later filed to enable the application to comply with the formal requirements
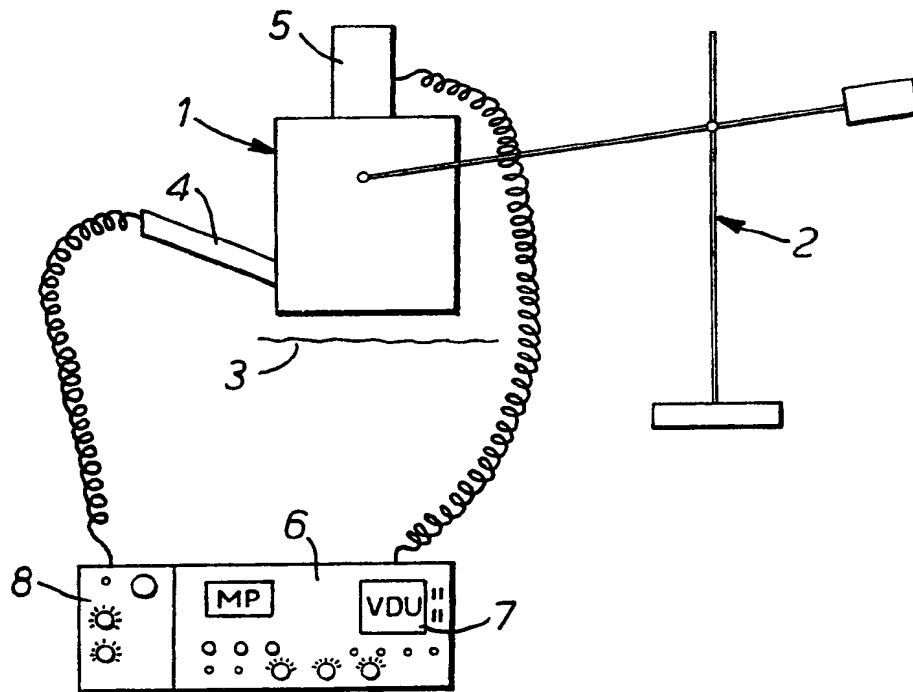of the Patents Rules 1978.

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FIG. 1.

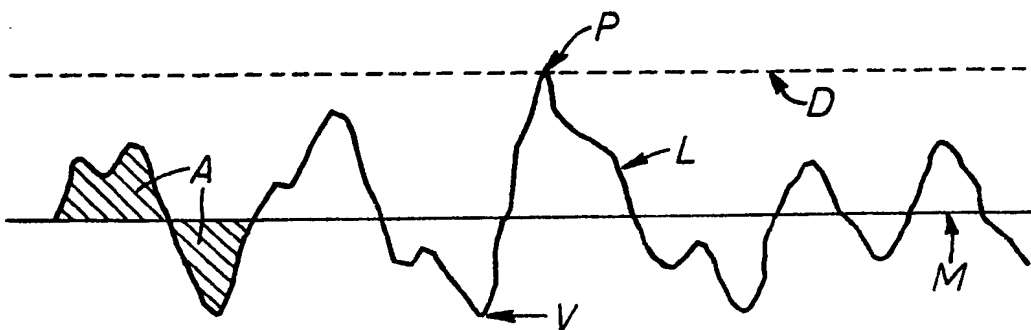FIG. 2.

SPECIFICATION
**Improvements relating to methods and
apparatus for measuring surface roughness**

This invention is concerned with means for
5 measuring the roughness of surfaces, for example
the surface of human skin. It is often necessary to
be able to assign a value to skin roughness, such
as when monitoring the efficiency of skin care
cosmetic products. The extent to which such
10 products are effective in smoothing the skin
surface can be checked by analysing the degree of
roughness of the skin before treatment and at
intervals of time subsequent to treatment.
A conventional method of evaluating the
15 roughness of skin is to produce a very highly
resolved skin cast and then to pass a stylus over
the cast and produce a trace of the extent of
vertical deviation of the stylus as it moves over the
cast. However, this method is not very accurate for
20 various reasons. The application of the cast
material to the skin creates some distortion in the
skin texture, and it is a multistage process that
allows only a two dimensional evaluation to be
made because the stylus has a very fine point.
25 Furthermore, the stylus can damage and distort
the cast as it moves over it.
It is an object of this invention to provide means
whereby surface roughness may be analysed with
a reasonable degree of accuracy and without
30 affecting the surface under consideration whilst
the analysis is being carried out.
Accordingly, from one aspect, this invention
provides a method of determination of a scale
value for surface roughness comprising
35 illuminating the surface from a predetermined
direction, analysing the variations in the density of
light reflected from along a line portion of the
surface and calculating a roughness value from
the analysis of light density variation for that line
40 with reference to a standard value.
Such a method offers several advantages,
firstly the measurement is carried out without any
contact being made with the surface being
analysed so that no distortions to that surface are
45 created. Also the method can be performed very
rapidly (as compared, for example, with a method
where a skin cast has to be made and cured as a
first step). The method also enables
measurements to be made of desired portions of
50 the surface at will.
In the preferred embodiment, a scan line from
the output of a video camera directed at the
surface is analysed for light density variation.
Ideally the video camera output will be analysed
55 by an electronic analysis unit. If desired the output
from the video camera could be applied to
produce a trace on an oscilloscope.
An alternative method is to take a photograph
of the light reflected from the surface and light is
60 then passed through the negative photographic
image and the light density transmitted through
the negative is scanned along a desired line
portion for analysis of light density variation. This
has the advantage that a permanent photographic

65 record of the surface being analysed is provided
but it is a slower method than that utilising a video
camera.
It may be preferred that a graphical trace of the
light density variation should be printed in the
70 form of a permanent record. A roughness value
can then be determined from a mathematical
analysis of the curve of the graphical trace. For
example, the roughness value may comprise the
length of the curve over a predetermined length of
75 the line portion being analysed. This length could
be calculated by running a distance measuring
wheel over the curve. Other possible measures of
roughness value which could be calculated include
those calculated on the basis of the mean peak-to-
80 peak frequency or amplitude, the integral of the
area to both sides of a mean value, or a Fourier
analysis of amplitude frequency of a
predetermined portion of the curve.
Clearly where the method is carried out using a
85 video camera associated with an electronic
analysis unit, the unit itself can carry out the
required mathematical analysis electronically and
produce an output value which is a measure of the
surface roughness.
90 The invention also extends to apparatus for
determining a scale value for surface roughness
comprising a support for mounting the equipment
adjacent a portion of a surface to be analysed, a
light source for directing a beam of light at a
95 predetermined angle onto the surface, a video
camera for recording the light reflected from the
surface and an analysis unit linked to the output of
the camera which is designed to calculate a
roughness value based on variations in the density
100 of light reflected from along a line portion of the
surface, with reference to a standard value.
The invention may be performed in various
ways and a preferred embodiment thereof will
now be described with reference to the
105 accompanying drawing, in which:—
Figure 1 is a diagrammatic illustration of
apparatus for measuring the roughness of a
surface, and
Figure 2 is a graph illustrating a trace which
110 may be achieved using the apparatus of Figure 1.
The measuring apparatus shown in Figure 1
comprises a housing 1 carried by an adjustable
support structure 2 so that the lower end of the
housing 1 can be positioned at a predetermined
115 spacing from a surface whose roughness is to be
analysed, for example a skin surface 3. A lighting
source 4 projects a light beam at an angle down
onto the surface 3 and a video camera 5 records
the reflection from the surface 3. The output from
120 the camera 5 is led to a control unit 6 which
incorporates a microprocessor for analysing the
signals and a video display screen 7. A control
portion 8 is also provided for enabling the intensity
of the light produced by the lighting source 4 to be
125 varied.
The enlarged image of the skin, illuminated at a
constant angle, is an analogue of the texture or
nature of the skin surface, since raised portions of
the skin will create shadows and the height of

each raised portion will determine the length and intensity of each shadow. The display produced on the screen 7 will be a picture of the skin and the operator can choose a desired area in the form of
5 a line across the screen so that an adjacent pair of lines from the roster of the television image will be displayed as a single line trace on an oscilloscope such as in the form illustrated in Figure 2. This single line trace can be studied and will also be
10 analysed by the microprocessor within the control box 6 which will be programmed to provide standard roughness parameters.

Referring now to the trace in Figure 2, various reference parameters may be calculated as
15 follows. Firstly, the integral of the area (A) to both sides of a mean value (M) can be calculated and will obviously increase as the roughness of the skin increases. Another measurement is of the frequency or amplitude of the various peaks (P)
20 above the mean line (M). The plot can be divided into equal increments and by calculating the valley (V) to peak (P) height of each increment a mean valley to peak height can be calculated over the whole plot. Another useful measure of roughness
25 is the length of the trace line (L) over a predetermined length of plot. A surface roughness increases so tha number of peaks and valleys and the height and depth of these will increase, thus resulting in an increase in line length. Other
30 possible measurements are of the mean depth below a datum line (D) and the maximum height of the peaks (P) over the portion of the trace being analysed. Another measure which has been found to be of value is of the harmonic coefficients of a
35 Fourier series.

There are other methods of measuring roughness so as to assign a scale value to a particular sample. Of those discussed above, line length is a very convenient form of measurement
40 since it can be calculated readily by running a distance measuring wheel over the curve of the form shown in Figure 2.

CLAIMS
1. A method of determination of a scale value
45 for surface roughness comprising illuminating the surface from a predetermined direction, analysing the variations in the density of light reflected from along a line portion of the surface and calculating a roughness value from the analysis of light
50 density variation for that line with reference to a standard value.
2. A method according to claim 1, wherein a scan line from the output of a video camera directed at the surface is analysed for light density
55 variation.
3. A method according to claim 2, wherein the video camera output is analysed by an electronic analysis unit.
4. A method according to claim 2 or claim 3,
60 wherein the output from the video camera is applied to produce a trace on an oscilloscope.
5. A method according to claim 1, wherein a photograph is taken of the light reflected from the surface and light is passed through the negative
65 photographic image and the light density transmitted through the negative is scanned along a desired line portions for analysis of light density variation.
6. A method according to any one of claims 1
70 to 5, wherein a graphical trace of the light density variation is printed in the form of a permanent record.
7. A method according to claim 6, wherein the roughness value is determined from a
75 mathematical analysis of the curve of the graphical trace.
8. A method according to claim 7, wherein the roughness value comprises the length of the curve over a predetermined length of the line portion
80 being analysed.
9. A method according to claim 8, wherein the length is calculated by running a distance measuring wheel over the curve.
10. A method according to claim 7, wherein the
85 roughness value is calculated on the basis of the mean peak-to-peak frequency or amplitude, the integral of the area to both sides of a mean value, or a Fourier analysis of amplitude frequency of a predetermined portion of the curve.
90 11. Apparatus for determining a scale value for surface roughness comprising a support for mounting the equipment adjacent a portion of a surface to be analysed, a light source for directing a beam of light at a predetermined angle onto the
95 surface, a video camera for recording the light reflected from the surface and an analysis unit linked to the output of the camera which is designed to calculate a roughness value based on variations in the density of light reflected from
100 along a line portion of the surface, with reference to a standard value.
12. A method or apparatus for determination of a scale value for surface roughness substantially as herein described with reference to the
105 accompanying drawings.

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FIG.4

FIG.5